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The Evolution of Artificial Intelligence and Its Transformative Role in Education

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Abstract: Artificial intelligence (AI) is a set of technologies that simulate human reasoning and decision-making, with applications in almost all spheres of society, including education. Starting from historical foundations, such as the work of Alan Turing and the emergence of the first chatbots, the paper shows how the development of AI, especially generative artificial intelligence (e.g. ChatGPT), has been reflected in the emergence of new tools and services. The impact of AI on education is also explored through the personalization of learning, the automation of evaluation and administrative processes, as well as support for teachers. The paper also points to challenges such as technology addiction, issues of ethics, privacy and automated bias. Special attention is paid to the future of AI in education and the need for an ethical, inclusive and transparent approach to the integration of these technologies. The paper aims to stimulate critical thinking about the role of AI in contemporary education.

Keywords: *Artificial Intelligence, Generative AI, Education, Machine Learning, Personalized Learning.*

Introduction

If we want to express ourselves in the simplest language, and in the shortest possible context, we can say that artificial intelligence is a set of smart (innovative) technologies that simulate human understanding. All these technologies have contributed to the formation of new disciplines that have advanced far with the help of interactive chatbots, predictive forecasting and much more. Back in the fifties, John McCarthy coined the term "artificial intelligence" at a conference on artificial intelligence (Dartmouth Conference in 1956). Already in 1965, ELIZA (Joseph Weizenbaum) appeared, the first chatbot that simulates a psychotherapist – the beginning of human-machine interaction. Namely, the predecessor of chatbots was a chatbot that was then used to simulate therapy in a question-and-answer format. The tendency to attribute human characteristics to "machines" and to have them reason and make decisions on their own, automate and mechanize processes is a hallmark of artificial intelligence itself. The 1980s and 1990s saw the development of expert systems (MYCIN, XCON) and criticism of AI for exaggerated expectations (James Lighthill – "AI Winter"). James Lighthill, a British mathematician and fellow of the Royal Society, is credited with a 1973 report that criticized the achievements of artificial intelligence up to that point. His "Lighthill Report" concluded that AI had not met expectations in real-world applications and recommended a reduction in research funding. This led to the first "AI winter" — a significant decline in interest and investment in AI during the 1970s. The question was whether we would even need AI in the future? The further period from 2000-2010 is characterized by the application of machine learning in industry (e.g. recommendations on Amazon, Google Translate). The emergence of large data sets (big data) would be a turning point in 2012, characterized by deep learning and neural networks achieving success in image recognition (ImageNet). In general, from November 2022, with the release of ChatGPT as a public tool, reaching 1 million users in 5 days – the era of generative AI begins. Already from 2023-2024, competitors such as Google Bard, Gemini, Microsoft Copilot and the short-lived DeepSeek as the Chinese answer to ChatGPT are developing.

The development of AI drew particular attention with the appearance of ChagGPT, which provided breakthrough assistance in all areas of daily life and work. A little later, the Chinese DeepSeak also ap-

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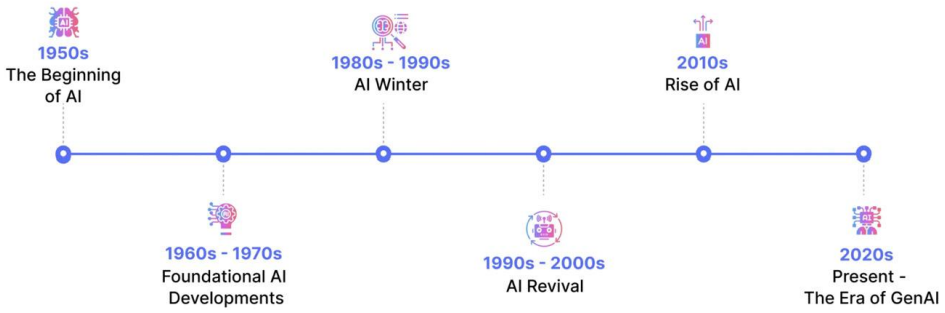
peared, but it has not yet dominated and achieved success like ChatGPT. Regardless of their recent appearance and breakthrough, AI itself dates back to the 1950s, when Alan Turing published a paper entitled “Computing Machines and Intelligence”, where even then he posed the now far-known question: “Can machines think?”, from which the “Turing Test” was born, with which people tried to distinguish between computer and human responses. How the development of AI has moved historically can be seen on Graph 1.



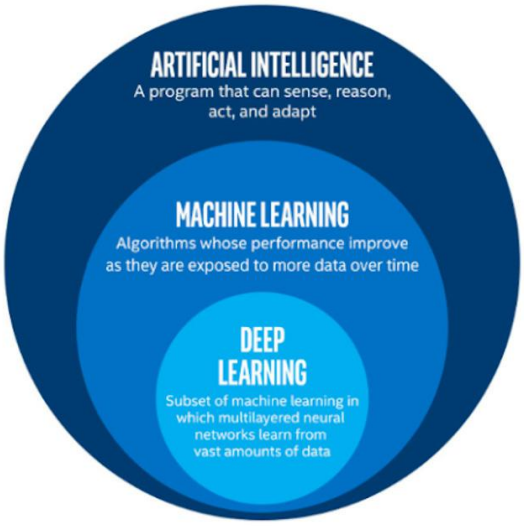
Graph 1. A historical timeline of AI
Source: https://www.openxcell.com/artificial-intelligence/

Despite several ups and downs, we are still seeing an increase in interest in machine learning, algorithmic decision-making and the provision of cognitive services (Mitrou, 2018). AI was originally designed to automate and speed up work processes and thus help in performing everyday tasks that were prone to errors. From simple automatic tasks, the application of AI has taken its place in everyday activities and all spheres. Everyday help with the help of chatbots is widely known to everyone and has become an integral part of everyday life and work. We are increasingly using AI applications and tools to get faster solutions, answers, and any kind of help. AI simplifies data management, processing, storage, and further use at a much faster and more advanced level. We are witnessing progress in all spheres with the help of AI every day. It is all these types of help that allow us to be more agile, more efficient, and far more transparent.

In artificial intelligence, we usually distinguish between two goals: “artificial general intelligence”, also known as “strong artificial intelligence”, and “artificial specialized intelligence”, also known as “weak artificial intelligence”. Artificial general intelligence aims to develop computer systems that exhibit most human cognitive abilities, at a human or even superhuman level, while artificial specialized intelligence aims at a more modest goal, building systems that are capable of performing specific tasks that require intelligence (Mitrou, 2018). One of the main advantages of artificial intelligence is that its decisions are based on facts, not emotions (Khanzode & Sarode, 2020, p. 34).

Further development of artificial intelligence - Market growth and trends

AI itself is the basis of numerous technological achievements, starting from machine learning, through deep learning, NLP... What confuses most and what is not clear to most is „How does AI work?“ Everyone talks about using AI tools, that everyone uses AI in their daily work, numerous quasi-experts in the field of AI appear without formal education and special courses, without work experience, but most basically do not know how AI itself works and where the line between legal, moral and ethical matters is. Mere knowledge and use of AI tools does not give many the right to say that they are experts in using AI tools. We have witnessed numerous AI courses where many experts who train in the use of AI and AI tools have emerged „overnight“ and do not know the principle of their operation. AI itself is „fed“ by daily data entry and user testing. Most do not even know that all data entered in the „free“ version is recorded somewhere and the AI itself learns from them, in addition to numerous databases and access to the Internet itself. Basically, there is a hierarchical relationship within AI itself (Graph 2).

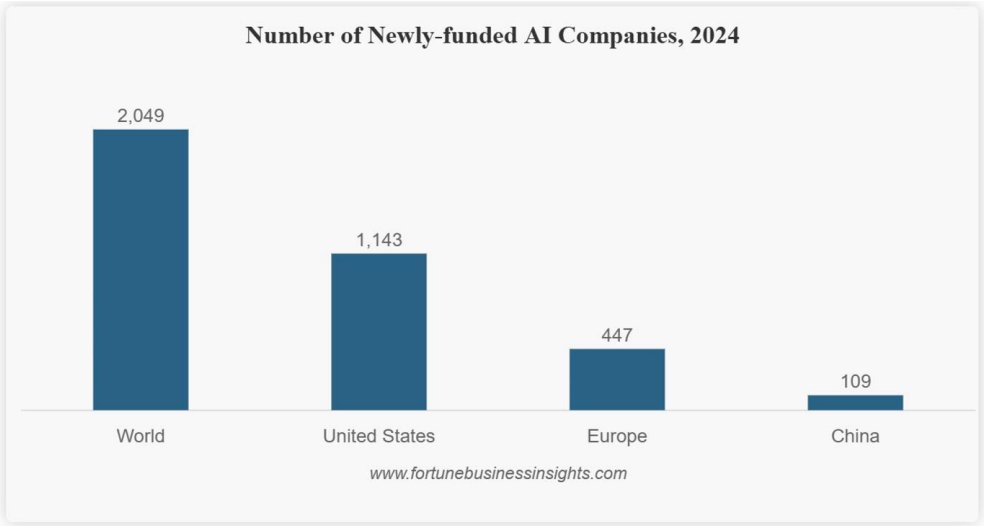


Graph 2. Hierarchical relationship between AI, ML and DL
Source: https://builtin.com/machine-learning/deep-learning

The attached clearly shows the hierarchical relationship between artificial intelligence (AI), machine learning (ML) and deep learning (DL). Artificial intelligence (AI) is the broadest term and includes programs that can perceive, reason, act and adapt. Machine learning (ML) is a subset of AI and refers to algorithms that improve their performance by learning from data over time. Deep learning (DL) is a specialized subset of machine learning that uses multi-layer neural networks to learn from large amounts of data. The AI itself is based on neural networks that use machine learning and deep learning. Basically, AI itself is based on the training of large amounts of data that are publicly available and that are fed daily by the use of all users.

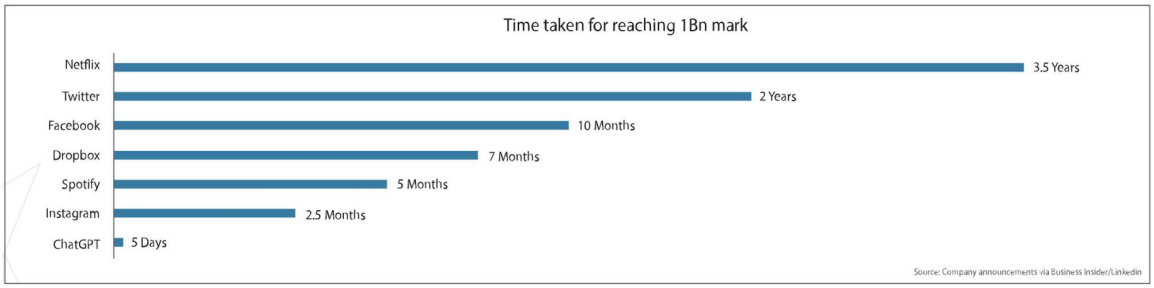
Regardless of the ups and downs, AI created a new digital evolution that took advantage of modern technologies. What is certainly clear is that AI is certainly not going away anytime soon.

Many companies are turning to AI technologies to analyze data and make informed decisions, with around 35% of businesses already integrating AI and 9 out of 10 organizations using this technology to maintain a competitive edge in the market. Governments around the world are investing significantly in the research and development of AI technology, and according to Goldman Sachs, global investment in AI will reach about 200 billion USD by 2025 (Graph 3).



Graph 3. Number of Newly-funded AI Companies, 2024
Source: https://www.fortunebusinessinsights.com/industry-reports/artificial-intelligence-market-100114

What caught everyone's attention was that OpenAI attracted more than a million users with its ChatGPT tool within just five days of its release in November 2022. Other companies took an unprecedentedly longer time to introduce their tools and online platforms to the market and achieve success (Graph 4).



Graph 4. Time taken reaching 1 Bn mark
Source: https://www.fortunebusinessinsights.com/industry-reports/artificial-intelligence-market-100114

Artificial Intelligence in Education

Along with all areas of human life, artificial intelligence (AI) has not bypassed education. Intelligence is not only about what is certain, decontextualised, disembodied, tokenised and reduced to its parts, so that it is predictable and controlled. It is also about understanding things that are fluid (Cukurova, 2025). The contribution that AI makes to education is the personalisation of teaching, the automation of administrative tasks and support in learning and assessment. In this way, both the teaching process and the work itself are made easier for teachers. If we look at the advantages provided by artificial intelligence, the introduction of artificial intelligence (AI) in education alone represents a significant potential for improving the quality of teaching and learning (Stošić & Janković, 2024). AI will certainly contribute to a profound transformation of the teaching process, which will be more interactive and adaptable to each individual. The question remains of ethical and social challenges. The question is whether AI will replace teachers? Of course not. They will be replaced by teachers themselves, who will be trained to use AI tools in education, which will serve as intelligent support for pedagogical decisions. AI will enable immersive, voice-guided interactions (e.g. in VR environments), predict risks of failure and recommend intervention measures. It is inevitable that tools like ChatGPT will be increasingly used to generate quizzes, plans and content. Due to its increasing availability and use, strict rules will be needed to protect student data and transparency of algorithms. A careful and ethical approach to artificial intelligence can maximize its benefits.

Artificial intelligence is used in higher education in a variety of ways, from detecting plagiarism and ensuring exam security to providing support to students through chatbots, improving online learning, transcribing lectures, monitoring student progress, supporting research... Chatbots respond contextually to different questions and instructions and provide differentiated feedback (Huang et al., 2022). Artificial intelligence adapts educational content to the unique learning style and pace of each student. AI-driven platforms (DreamBox and Smart Sparrow) assess students' skill levels in real time and adapt teaching content to individual needs. For people with special needs, AI tools can recognize speech and transcribe it into text. In general, we can't help but wonder if artificial intelligence is good or bad for education? Artificial intelligence (AI) is neither good nor bad for education – its impact depends on how it is designed, implemented and controlled. AI in education brings numerous benefits, but also significant risks that need to be carefully managed. Artificial intelligence can be a powerful ally in improving education, but only if it is developed ethically, inclusively and transparently. One of the potential drawbacks is the dependence on technology, which makes individuals less likely to develop critical thinking and problem-solving skills. The collection of sensitive information without clear regulation is another significant drawback that must not be omitted or ignored. Data and information must be used in a sufficiently large sample and transparently to avoid automated bias, i.e. AI can amplify inequalities if the data or models are biased. The potential risk of replacing the role of teachers still exists, but for now, AI cannot generally replace teachers.

Generative AI and tools - Impact on work and everyday life

When we talk about artificial intelligence, we cannot help but mention and explain the term generative artificial intelligence. Generative artificial intelligence is a part of artificial intelligence that deals with the development of models that can create new content without directly copying existing examples. These can be texts, images, videos and other media. Currently, the latest generation model GPT-4 accepts both image and text inputs to generate text output (Achiam et al, 2023). The aforementioned models are often used to support data-driven decision-making (Ng & Jordan, 2001). Many artificial intelligence models used in business analytics are difficult to understand for people who are not sufficiently computer literate (Senoner, Netland & Feuerriegel, 2022). The basis of generative artificial intelligence is information from a large number of data that, using various techniques (neural networks, generative models), generates new content that is closest to what is required. Deep neural networks can be designed using different architectures to model different types of data (Janiesch et al. 2021; Kraus et al. 2020). Generative artificial intelligence has the potential to transform domains and industries that rely on creativity, innovation, and knowledge processing (Fui-Hoon Nah et al., 2023, p. 123).

In the sphere of education, generative artificial intelligence offers various tools that enable the management of educational processes, thus improving the work of teachers and the teaching itself. Generative AI tools can create lessons, texts, and other types of teaching materials. They offer different answers and examples, according to the individual needs and level of knowledge of the students. Another advantage is the provision of answers in real time, which allows you to get answers and explanations in any volume, create lessons, quizzes, games, and all in order to facilitate learning of the material. Special importance is given to chat bots, which have made a real revolution. ChatGPT, with the version of ChatGPT3, marked the era of generative artificial intelligence in June 2020 to reach its peak in November 2022. The emergence of ChatGPT has encouraged companies to actively engage and invest in AI technologies to utilize these AI-based tools. Very quickly, ChatGPT also got its competitors - Google Bard, Microsoft Bing, Google Gemini... There was a race between OpenAI, Google, Apple, Microsoft over numerous AI tools and services. While numerous companies insisted on the mandatory use of these AI tools with the payment of the full version, others expressly forbade their use.

Generative AI will certainly have a much greater impact on global productivity. This is in line with the general demand to redirect working time towards more efficient use as automation increases between 2022 and 2040 (Kraus, Feuerriegel, & Oztekin, 2020). The global AI market is projected to grow to US$2,740.46 billion by 2032, with a compound annual growth rate of 20.4% between 2024 and 2032. By 2027, almost half of the workforce (44%) will need to change or modify their core skills due to AI, according to the World Economic Forum (https://www.openxcell.com/artificial-intelligence/). The global AI market was estimated at US$233.46 billion in 2024. The market is projected to grow from USD 294.16 billion in 2025 to USD 1,771.62 billion by 2032, at a compound annual growth rate (CAGR) of 29.2% during the forecast period (https://www.fortunebusinessinsights.com/industry-reports/artificial-intelligence-market-100114).

Ethical and societal challenges

Privacy and data security

Of course, one of the challenges in using artificial intelligence is the protection of privacy and data security. If we talk about education, artificial intelligence systems will work with a large amount of personal data, the most sensitive of which is biometric data. In particular, care should be taken to ensure that everything complies with GDPR or FERPA standards in order to avoid misuse, data leakage or unauthorized surveillance. As early as 2017, many legislative initiatives and proposals were launched by the EU and the UK regarding the impact of artificial intelligence on society, covering issues of liability, legal subjectivity and other ethical and legal issues, including the context of data processing (Butterworth, 2018). The misuse of data itself can lead to user distrust in the AI systems themselves, which entails numerous legal and ethical consequences. Security threats can affect users' trust in AI systems and lead to legal and ethical consequences. Teachers should certainly be aware of the relevance of ICT use in the context of teaching and learning. More on this issue can be found in the work of Łukasz Tomczyk and colleagues (Tomczyk, Ł. Et al, 2020). The security challenges facing the digital realm are expanding exponentially due to the increasing connectivity of numerous devices, applications and platforms (Mallikarjunaradhya, Pothukuchi & Kota, 2023). Tools available on the internet, both commercial and free, are not designed to prevent security (Stošić & Veličković, 2013). It is inevitable that institutions must take appropriate measures to

protect student privacy and prevent bias (Harry, 2023). No matter how many human laws it may break, artificial intelligence is not inherently evil. Artificial intelligence possesses divine characteristics; it is an entity beyond the realm of good and evil. No matter how hard programmers try to align artificial intelligence with the moral principles of human society, artificial intelligence eludes such efforts (Filipović et al, 2023).

Algorithmic bias poses a serious threat to the fair and objective application of AI technologies. Given that machine learning models learn from historical data, if that data contains social inequalities, the results of AI systems can reproduce or reinforce discriminatory patterns. In an educational context, this can mean unequal treatment of students from different socioeconomic or ethnic backgrounds, incorrect predicted grades, or selective availability of supports. To overcome this problem, measures such as auditing algorithms, including diverse and balanced data sets, and improving transparency in explaining how algorithms make decisions are needed. The ICO identified five distinctive aspects of big data analytics using artificial intelligence with implications for data protection in its 2017 document (Act, D. P., & Regulation, 2017). The purpose of data collection and analysis must be clear and must comply with standards. Ethical and data protection input will be required at the design stage, training stage and throughout implementation (Butterworth, 2018).

With the popularity of artificial intelligence, so-called "AI experts" without formal knowledge or experience are increasingly appearing. The rapid commercialization of AI education, especially through short online courses without scientific or pedagogical verification, leads to the spread of unreliable information and a decrease in the quality of professional staff. The consequence of this phenomenon is a misunderstanding of the functions of AI tools, as well as reckless implementation in practice. In order to ensure the quality and integrity of knowledge in this area, it is necessary to support training through institutions as well as numerous accredited programs and professional mentoring.

Conclusion

It is inevitable that artificial intelligence will bring numerous benefits – from personalized learning and more effective teaching, to improved data analysis and process automation. It is also inevitable that AI will transform education itself. The application of generative tools such as ChatGPT will be an indispensable tool in everyday life. In addition to all the advantages, care must be taken, from threats to privacy and data security, to algorithmic bias, to the spread of uncritically adopted or inaccurate information. The future of AI depends not only on technological progress but also on our ability to use it ethically, responsibly and transparently. Cooperation between the academic community, educational institutions, government bodies and technology companies in the development of regulatory frameworks, digital literacy and training of teaching staff is necessary. Education programs that enable the development of digital literacy among students, teachers and parents must be introduced. Only carefully managed integration of AI can ensure that it remains at the service of humans – as a tool for advancing knowledge, not a replacement for human wisdom.

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